Fabrication of Superhydrophobic Materials Through Femtosecond Laser Ablation

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In past decades, superhydrophobic materials have found increased applications in industry due to their convenient self-cleaning, anti-icing, drag-reducing, and corrosion resistant properties. Chemical coatings such as per- and polyfluoroalkyl substances (PFAS) have traditionally been used to grant materials water repellent effects, but these coatings can be expensive and difficult to prepare, with many being non-biodegradable and toxic upon accumulation. In this research, surface modification via femtosecond laser ablation was explored as a promising alternative. Surface structures on the base material, formed with ultra-short laser pulses, increased surface roughness to promote Cassie-Baxter wetting (trapped air pockets between water droplets and the textured surface minimize contact area and adhesion). Numerous distinct laser parameters were tested by analyzing treated surfaces for apparent contact angles as indicators of superhydrophobicity. Afterwards, a series of stability tests were done to assess practicality in various environments. Throughout experimentation, high contact angles (>150°) were maintained consistently under a multitude of conditions, demonstrating excellent stability and potential for practical applications. Additionally, surfaces exhibiting superior water repellent effects were shown to lose superhydrophobicity with significant wear from abrasion, indicating a strong correlation between surface topography and superhydrophobicity. This study examined the great potential of femtosecond laser ablation as an alternative approach to surface modification for superhydrophobicity. Further design refinements aimed at scaling up production and increasing durability will likely be the next step to industrial application.